

**The NASA Lewis
Research Center's
Expendable
Launch Vehicle
Program:**

**An Economic
Impact Study**

Prepared for
The NASA Lewis Research Center
By
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Executive Summary

Introduction

This study investigates the economic impact of the Lewis Research Center's (LeRC) Expendable Launch Vehicle Program (ELVP) on Northeast Ohio's economy. It was conducted by The Urban Center's Economic Development Program in Cleveland State University's Levin College of Urban Affairs. The study measures ELVP's direct impact on the local economy in terms of jobs, output, payroll, and taxes, as well as the indirect impact of these economic activities when they "ripple" throughout the economy. The study uses regional economic multipliers based on input-output models to estimate the effect of ELVP spending on the Northeast Ohio economy.

Program History and Background

The Expendable Launch Vehicle Program (ELVP), managed by the Lewis Launch Vehicle Project Office, was established in 1962 when the Atlas/Centaur program was transferred to LeRC from Marshall Space Flight Center in Alabama. LeRC was assigned to manage the Atlas/Centaur Program because of its expertise with liquid hydrogen and propulsion technology.

At present, ELVP's primary objective is to procure and manage launch services for government payloads launched on intermediate (Atlas/Centaur class) and large class launch vehicles (Titan IV class). ELVP's commercial launch services approach provides low cost, low risk launches for government payloads which are unique national assets that support planetary exploration, environmental science, solar science, weather monitoring, and communication.

Since 1962, the ELVP has been responsible for 118 launches of Atlas, THOR, Titan, and other vehicles with various upper stages including Agena and Centaur; nine of these launches were test flights. ELVP's launched missions have been conducted with a high level of success over the past 30 years. Until the Challenger accident in 1986, Lewis Research Center's ELVP directly managed

the Atlas/Centaur program. Following this accident, the National Space Policy was changed to encourage commercialization of space launches. To comply with the new policy, ELVP developed an innovative approach to implement the new commercial launch services, establishing a relationship between the prime contractor, who builds the launch vehicle, and NASA, ensuring the contractor's response to government needs.

Since the commercialization of space launches, ELVP has had a 100% launch success record. It has obtained launch service prices which are best in the government and are equivalent to or less than those paid by commercial satellite companies. Costs in a program of \$670 million increased by only 1.1% over the past eight and a half years .

Major Findings

- ELVP accounts for a large portion of LeRC's R&D budget but has relatively few employees. It accounted for 25% - 30% of LeRC's R&D budget during each of the past five years and for 2.7% of LeRC's total number of employees in FY 1995. The ELVP employed 121 people in FY 1995; 82 civil service employees and 39 contract employees.
- Over the five-year period, FY 1992-1996, total salaries and benefits of ELVP's civil service employees are estimated to reach \$28.4 million. In FY 1995, total salaries and benefits amounted to \$6.3 million. Average salary and benefits for an ELVP employee is estimated to be \$78,800 in FY 1996, a sum which is 12.2% higher than LeRC's average compensation.
- Scientists and engineers account for 89% of ELVP's employees, which is a significantly higher share than at LeRC as a whole (56%).
- Over the ten-year period, FY 1991-2000, total ELVP spending in Northeast Ohio is estimated to amount to \$59 million. This accounts for about 5% of ELVP total spending on contractors. ELVP's main contractor is Lockheed Martin, which is located in Denver, Colorado. Unfortunately, following mandated streamlining initiatives, total and local spending levels are projected to decline significantly between FY 1997 and FY 1998 and then continue to decline moderately until the end of the decade.
- During FY 1995, the ELVP spent \$7.6 million to purchase goods and services from Northeast Ohio companies. Similarly to LeRC's spending patterns, the economic sector in Northeast Ohio that benefitted the most from ELVP's contractor spending is engineering and business services. Of ELVP's local spending, 73% was for purchasing engineering and

business services compared with LeRC's 66%. The only other industry where ELVP spent locally more than one million dollars in FY 1995 was communication, accounting for almost 15% of local spending.

- During the five-year period, FY 1992-1996, ELVP employees are expected to pay \$1.4 million in taxes to state and local governments. One-third is paid to local communities where ELVP employees reside or work and the other two-thirds is paid to the state of Ohio.
- ELVP's economic benefits to Northeast Ohio in FY 1995 amounted to a total output impact of \$35 million, total employment impact of 413 jobs, and a total earnings impact of \$13 million.

Conclusions

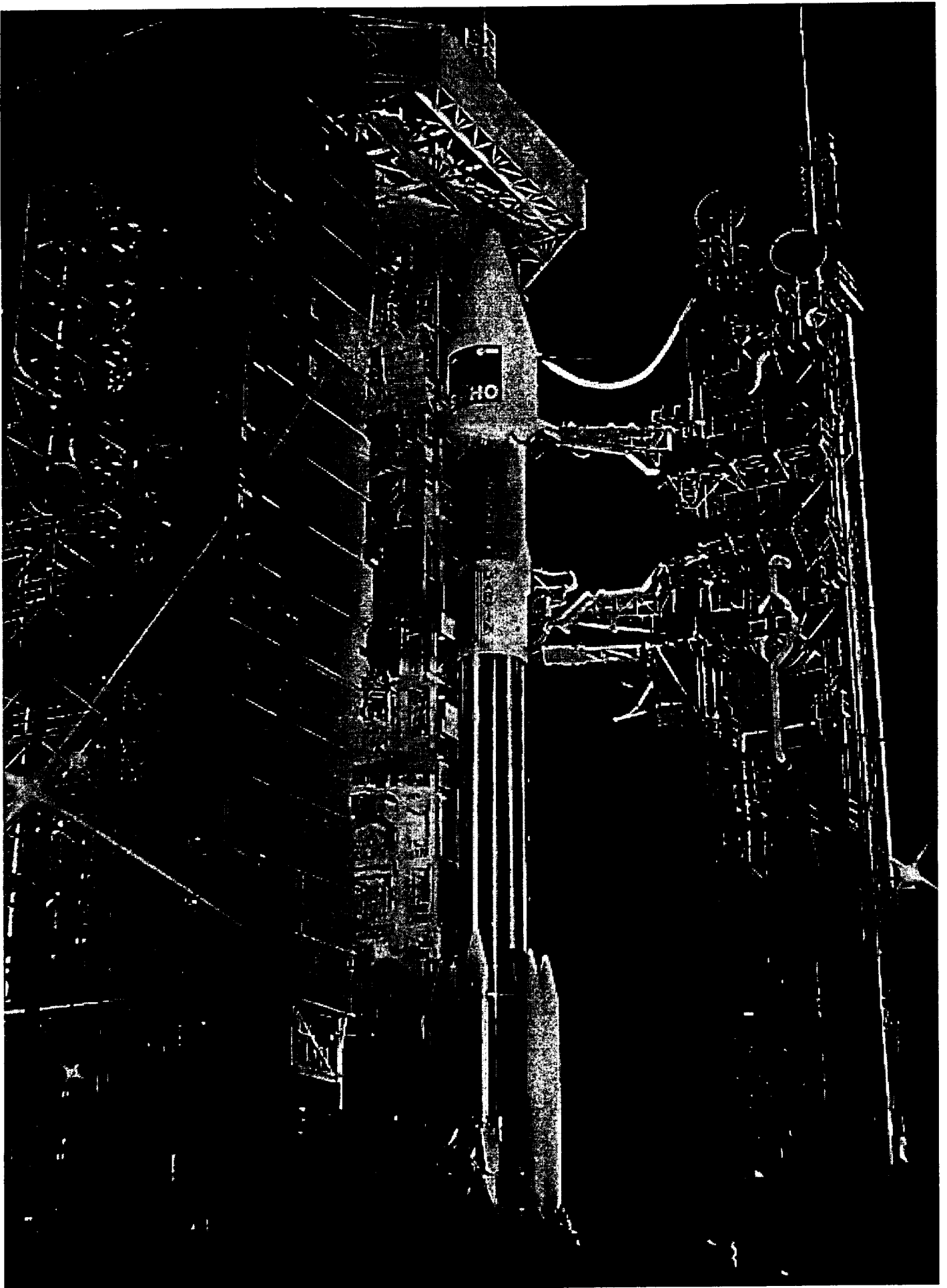
The Lewis Research Center's Expendable Launch Vehicle Program plays an important role in LeRC's mission of research, technology, and development in areas of aeropropulsion and selected space applications. LeRC is a major research and development producer and the ELVP accounts for one-fourth of its spending on R&D. Therefore, LeRC and the ELVP comprise a crucial part of Northeast Ohio's science and technology base.

If the ELVP relocates from Lewis to another NASA Center (as has been suggested by NASA Headquarters), LeRC's budget will decline significantly. A smaller LeRC budget would make it easier to justify additional budget cuts for a Center that already would have lost a fourth if its R&D budget and much of its expertise. LeRC's large economic impact on Northeast Ohio would decline if its budget, employment, and spending would decline significantly. LeRC's economic benefit to the regional economy is attested by its sizable total output impact of \$1 billion, employment impact of 12,800, and household earnings impact of \$375 million.

Recommendations

The Urban Center offers the following recommendations:

1. LeRC's ELVP workforce, comprised largely of highly skilled scientists and engineers, offers collectively over 1,000 years of experience with expendable launch vehicles. If the ELVP were to transfer to another NASA Center, it could take years to replace this expertise, since many of these people may not relocate with the program. Considering LeRC's ELV expertise and long history of success with this program, NASA should weigh the benefits of moving the ELVP against possible adverse impacts, including added costs, increased risks, less skillful and experienced workforce, and employee morale.
2. The exciting work of launching expendable vehicles to space is recognized by the public. However, ELVP's critical role in the success of these missions is not generally known to local leaders, communities, and the public. Thus, it is recommended that both LeRC and its ELVP make their achievements known to Northeast Ohio communities. LeRC and the ELVP should work more closely with key community organizations such as Cleveland Tomorrow and its Technology Leadership Council, the Greater Cleveland Growth Association, and the Ohio Science and Technology Commission to spread the word about ELVP's activities and successes.
3. ELVP should foster relationships with area universities. One avenue to build new relationships could be through the Ohio Aerospace Institute (OAI). OAI is a private, non-profit, university-industry-government consortium that includes LeRC in Cleveland, Wright-Patterson Air Force Base in Dayton, nine Ohio universities, and technology driven corporations. Through OAI, or working directly with individual universities, ELVP's scientists and engineers could expose graduate students to rocket science in general and to expendable launch vehicles technology in particular. This strategy would provide a unique contribution to the education level in Ohio as well as expose universities' faculty, graduate students, and staff to ELV missions.





I. Statement of Purpose

This report presents the results of a study of the economic impact on Northeast Ohio's economy of the Expendable Launch Vehicle Program (ELVP) at the National Aeronautics and Space Administration's Lewis Research Center (LeRC).¹ The study was conducted by The Urban Center at the Levin College of Urban Affairs, Cleveland State University (CSU) as a supplement to the larger study of LeRC's impact on Northeast Ohio.²

Economic impact studies help industry and community leaders understand how an institution, or a program, affects the economic health of a region. These studies look at the institutions' or programs' direct impact as well as the benefits that spill over to parties in and around it. Typically, economic multipliers are used to measure impact in terms of regional output, employment, and household earnings. Other economic impact studies that were performed for local organizations include those of the Playhouse Square Development Project (1987), the Rock and Roll Hall of Fame (1989), the Cleveland Arts Consortium (1991), Cleveland State University (1992), the International Exposition Center (1994), the Cleveland Clinic Foundation (1995), and NASA Lewis Research Center (1996). The last four studies were conducted by CSU's Urban Center.

This study's purpose is twofold:

1. Provide ELVP managers and LeRC leadership with strategic information on ELVP as an important segment of the research and development activities at LeRC.
2. Provide an independent assessment of the contribution of LeRC's ELVP to the Northeast Ohio economy.

¹Northeast Ohio includes the eight counties within the Cleveland and Akron metropolitan areas: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit.

²The original study entitled *The NASA Lewis Research Center: An Economic Impact Study* was published on February 12, 1996.

II. LeRC's Expendable Launch Vehicle Program: Background

The Lewis Research Center (LeRC) is one of ten National Aeronautics and Space Administration (NASA) research and development centers.³ The Expendable Launch Vehicle Program (ELVP), managed by the Lewis Launch Vehicle Project Office, was established in 1962 when the Atlas/Centaur program was transferred to LeRC from Marshall Space Flight Center (MSFC) in Alabama. Atlas/Centaur was initially designated the launch vehicle for Surveyor, the unmanned lunar lander program, and its success provided the foundation for a wide variety of launches to the present day. To provide an understanding of the program, the following sections describe ELVP's objectives, history, tasks, current and future missions, and program organization.

1. ELVP Objectives

Primary objective:

- Procure and manage launch services for government payloads launched on intermediate (Atlas/Centaur class) and large class launch vehicles (Titan IV class).

Secondary objectives:

- Help to enhance the existing Expendable Launch Vehicle Fleet to provide cost savings or improvements in performance, reliability, and operability.
- Support NASA Headquarters for the overall Expendable Launch Mixed Fleet Program integration including coordination with Goddard Space Flight Center for small and medium vehicle classes and with Kennedy Space Center for launch operations support.

³LeRC is situated on 350 acres of land and occupies more than 140 buildings, and over 500 specialized research and test facilities. Lewis is the mission Center for Aeropropulsion and develops technology for selected space applications. It has been designated as the Center of Excellence for turbomachinery. Lewis performs research and technology development in support of aeronautical propulsion, space power, on-board propulsion, and space communication, with technical expertise in microgravity fluid and combustion research, and commercial communications.

2. ELVP History

Lewis Research Center was assigned to manage the Atlas/Centaur program in 1962 because of its expertise with liquid hydrogen gained by conducting research on that fuel since the 1950s. Centaur upper stage was a development program needed for the success of a lunar landing in the Surveyor program, and paved the way for manned lunar landings. Receiving the program provided LeRC with a challenge consistent with LeRC's expertise in propulsion technology: developing the technology of a cryogenic high energy upper stage, which utilized liquid hydrogen and liquid oxygen for the first time.

Since 1962, the ELVP has been responsible for 118 launches of Atlas, Titan, and other vehicles with various upper stages including Agena and Centaur; nine of these launches were test flights. Appendix A provides a detailed list of LeRC's launched missions and the year they were launched. Appendix B shows the high level of success over the past 30 years of launching missions by ELVP. ELVP's main achievements include:

- Development of the high energy upper stage Centaur to accomplish the Surveyor moon landing. Between 1962-1966 eight R&D test flights were flown to qualify the Centaur D stage for the Surveyor lunar landing missions. All seven missions were successfully launched during 1966-1968.
- The Atlas/Centaur continued to be upgraded throughout the 1960s, 1970s, and 1980s and became a very dependable member of NASA's launch vehicle fleet. In the late 1970s and early 1980s it was modified for use in the Space Shuttle. Shuttle Centaur was cancelled following the Challenger accident and never flew.
- Development of the Titan Centaur for the Helios solar missions, the Viking Mars missions, and Voyager missions to the outer planets.

These and other developments by LeRC's ELVP have led to a number of "firsts". These historical milestones include:

FIRST use of liquid hydrogen as a propellant in the development of the Centaur high energy upper stage.

FIRST controlled soft landing (in the free world) of a spacecraft on the moon.

FIRST interplanetary missions to Venus and Mars and the first mission to orbit the moon.

FIRST interplanetary probe to orbit Mars.

FIRST missions to Jupiter and Saturn.

FIRST spacecraft to escape the solar system.

FIRST look at Mercury.

FIRST capability to explore the outer planets of the Solar System, including Uranus and Neptune.

Until the Challenger accident in 1986, Lewis Research Center's ELVP continued to directly manage the Atlas/Centaur program. Following this tragic accident, the National Space Policy was changed to encourage commercialization of space launches. To comply with the new policy, ELVP developed an innovative approach to implement the new commercial launch service program, establishing a relationship between the prime contractor, who builds the launch vehicle, and NASA to assure the contractor's response to government needs. Since that time the ELVP has realized the following achievements:

- A 100% launch success record (five for five).
- Cost increase of only 1.1% over the past 8 1/2 years in a program of \$670 million.
- Obtaining launch service prices which are best in the government and equivalent to or less than those paid by commercial satellite companies.

3. ELVP Current Tasks

ELVP's commercial launch services approach provides low cost, low risk launches for government payloads which are unique national assets. These missions are launched to conduct planetary exploration, environmental science, solar science, weather monitoring, and communication. ELVP's approach maintains government involvement in several critical functions. These include:

- Managing the integration of payloads.
- Acquiring launch services.

- Performing independent verification and validation analyses for critical aspects of the missions.
- Conducting evaluation and approval of hardware and software designs unique to individual missions.
- Providing insight into the launch service contractor's design, production, and operations.
- Providing final product review of hardware, procedures, and readiness to launch.

4. ELVP's Current Spacecraft Customers and Active Missions

ELVP's current customers include:

- Goddard Space Flight Center
- Jet Propulsion Laboratory
- European Space Agency
- National Oceanic and Atmospheric Administration (NOAA)

These customers have rated ELVP performance very high; the most recent survey (December 1994) resulted in a customer satisfaction index of 4.2 out of 5.

Missions currently active and their scheduled launch dates are: Geostationary Operational Environmental Satellites⁴, GOES K (April-May 1997), GOES L (July 2001), and GOES M (August 1999); Cassini mission to Saturn (October 1997)⁵; Earth Observing System (EOS) AM-1

⁴The GOES spacecraft are designed to collect data in support of weather forecasting, storm tracking, and meteorological research. The spacecraft is delivered into a geostationary transfer orbit by an Atlas expendable launch vehicle. GOES-8 (GOES I) and GOES-9 (GOES-J) were launched on Atlas I vehicles from Kennedy Space Center in April 1994 and May 1995, respectively. After initial spacecraft checkout periods by NASA, both spacecraft were turned over to NOAA for operational use.

⁵The Cassini Mission to Saturn, scheduled to be launched on a Titan IV/Centaur vehicle in October 1997, achieved significant progress in FY 1995. Several major program reviews were conducted and cleared the way for the fabrication of the mission unique launch vehicle hardware. The basic Titan and Centaur vehicles are in the advanced stages of production. The focus is currently on integration and checkout of the launch vehicle and spacecraft and on launch operation.

(June 1998)⁶; and Tracking and Data Relay Satellite (TDRS) H (July 1999)⁷. Missions under study include a Crew Return Vehicle and logistics supply to support the International Space Station. Other potential missions include exploration of Pluto and a Sample Return from Mars.

5. ELVP Organization

Launch services at LeRC are implemented by the Launch Vehicle Project Office. This office consists of 26 core civil service personnel including four who are located on site at the Denver Resident Office at Lockheed Martin, the contractor for Atlas/Centaur and Titan expendable launch vehicles. In addition, 95 full-time equivalent positions held by civil service employees and support service contractors are dedicated to the ELVP. These include persons located at LeRC who devote portions of their time to the Program providing support in engineering, procurement, budget, safety, mission assurance, and mission analysis.

Individuals supporting the LeRC's ELVP bring collectively over 1,000 years of experience to the program, averaging over 14 years per employee. This significant level of specialized expertise has been a major contributor to a long and successful venture for LeRC, advancing U.S. capabilities in space propulsion and successfully launching government payloads.

⁶The EOS-AM-1 spacecraft is part of NASA's Mission to Planet Earth Program. The spacecraft is scheduled to be launched into a high inclination orbit from Vandenberg Air Force Base on an Atlas IIAS launch vehicle in June 1998. The EOS AM-1 spacecraft will provide detailed measurements of clouds, aerosols, and Earth's radiative energy balance, in addition to measurements of the land surface and its interaction with the atmosphere.

⁷The TDRS system that was implemented in the late 1980s produced a constellation of five satellites and a ground station to provide communication coverage for low Earth-orbiting satellites, the Space Shuttle, and Space Station programs. Each of these TDRS spacecraft was launched aboard the space shuttle. In order to reduce costs, all new TDRS spacecraft will be launched on expendable launch vehicles. The first launch of this new generation of TDRS spacecraft, under development by Hughes Space and Communication Company, is scheduled for July, 1999.

III. ELVP Direct Impact: Recent Trends and Projections

The Expendable Launch Vehicle Program (ELVP) accounts for a significant part of the research and development activities undertaken by the Lewis Research Center. This section describes ELVP budget, contract spending, employment, payroll, and taxes.

1. LeRC and ELVP Research and Development Budgets

During the first half of the 1990s, LeRC's Research and Development (R&D) budget accounted for about three-fourths of LeRC's total budget. LeRC's R&D budget share of its total budget is projected to increase as a result of the severe budget declines facing NASA and the streamlining of many administrative functions. The ELVP's R&D budget share of LeRC's R&D budget is projected to increase as well. As can be seen in Table 1, the ELVP's R&D budget has been fluctuating as a percentage of LeRC's R&D budget during the 1990s. In FY 1994, the ELVP's R&D budget accounted for about one-fourth of the LeRC's R&D budget; it is expected to increase to 31% in FY 1997, decline somewhat, and then increase again to 31% by FY 2000.

The size of ELVP's R&D budget indicates that the ELVP is a thriving program. However, ELVP is scheduled to move from LeRC to another NASA Center in FY 1999. The estimated ELVP budget assumes that the money will be spent by NASA on these missions, although the ELVP's location remains uncertain. Nevertheless, ELVP's R&D budget and its share of LeRC's R&D budget are calculated under the assumption that the program remains at LeRC (Table 1 and Figure 1). These shares suggest that ELVP's R&D budget accounted for at least one-quarter of LeRC's R&D budget in the mid 1990s and could account for 31% of R&D budget by FY 2000 if it is allowed to remain at Lewis. **If ELVP would leave Lewis in FY 1999, LeRC's R&D budget will be adversely affected.** If the ELVP is transferred to another NASA Center, LeRC's R&D budget will fall by 33% between FY 1998 and FY 1999; it is expected to decline by only 7.7% if the ELVP stays at the Lewis Research Center.

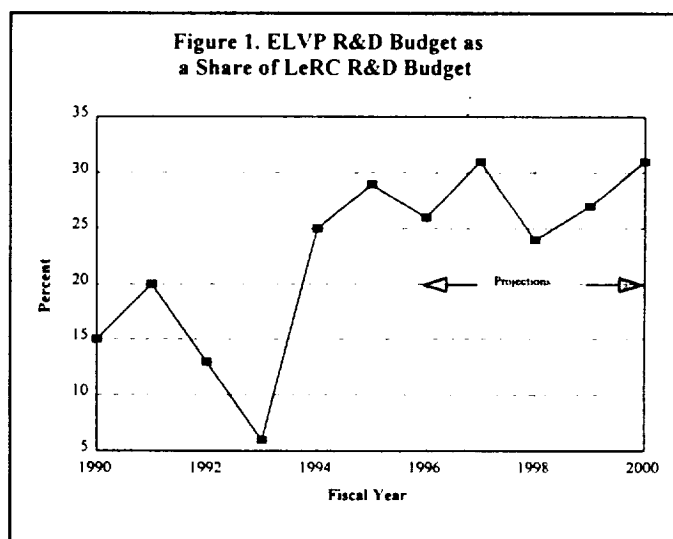
Table 1. LeRC and ELVP R&D Budgets, FY 1990 - FY 2000 (in \$ Millions)

| | LeRC R&D Budget* | ELVP R&D Budget** | ELVP % of LeRC | No. of Funded Missions |
|-------------|-----------------------------|------------------------------|-----------------------|-------------------------------|
| 1990 | 628.0 | 93.2 | 15% | 6 |
| 1991 | 746.9 | 149.6 | 20% | 6 |
| 1992 | 735.8 | 94.8 | 13% | 5 |
| 1993 | 818.3 | 51.5 | 6% | 5 |
| 1994 | 760.2 | 186.7 | 25% | 7 |
| 1995 | 629.2 | 184.0 | 29% | 6 |
| 1996 | 684.0 | 179.4 | 26% | 5 |
| 1997 | 669.5 | 207.1 | 31% | 6 |
| 1998 | 602.5 | 144.4 | 24% | 7 |
| 1999 | 556.1 | 151.6 | 27% | 6 |
| 2000 | 510.2 | 158.1 | 31% | 5 |

Notes:

*The ELVP is scheduled to leave LeRC and move to another NASA Center in FY 1999. However, R&D budgets for FY 1999 and FY 2000 assume that the ELVP stays at LeRC.

** ELVP budget is estimated without regard to where it is going to be located.



Throughout the decade the number of funded missions is projected to remain in the range of five-to-seven each year. The level of annual funding fluctuates depending on the mission's phase; in the earlier phases the level of required funding is lower because there is little hardware involved.

2. ELVP Labor Force

ELVP's labor force includes civil-service employees as well as on-site and off-site contractors as is typical of many LeRC projects. This dual approach is common among federal laboratories where only some of the employees are government workers. Contract workers give ELVP flexibility in managing the size of its workforce, by allowing the services to fluctuate according to program needs; hiring civil servants is more complex and more permanent. The sections that follow analyze the ELVP labor force in terms of number of employees, payroll, and occupational distribution.

A. Employment

Total full-time equivalent employment at ELVP was 121 at the end of FY 1995. The Program's FY 1995 end-of-year workers included 82 civil servants and 39 support service contractors' employees (Table 2).

Total ELVP full-time-equivalent employment increased by 42%, or 36, since FY 1990, contrary to employment changes at LeRC as a whole. LeRC's employment fell from 4,677 in FY 1990 to 4,444 in FY 1994, a 5% drop resulting from a 10.5 % decline in civil-service employment and a 4% increase in employment of on-site and near-site contractors. Contrary to overall trends at LeRC, of the 36 ELVP's new jobs , 28, or 78%, were civil service jobs. As a result, the share of civil-service employees increased from 64% of ELVP's total employment in FY 1990 to 68% in FY 1995.

From FY 1996 until the end of the decade, ELVP's total employment is projected to decline by 65%, with civil service employees absorbing the lion's share of job losses. Civil-service employment is

projected to decline by 71%, while employment by on-site/off-site contractors is expected to fall by 54% between FY 1995 and FY 2000. As can be seen in the table, severe cuts are projected between FY 1997 and FY 1998 and in each of the following two years. These projections take into account the severe budget cuts at NASA and mandated streamlining initiatives. Because of the dramatic pressures on many federal agencies to operate more efficiently with lower budgets, NASA projects that by the end of this decade, ELVP, as well as LeRC as a whole, will be much smaller, with significantly lower budgets and fewer employees. However, the projected number of ELVP funded missions will stay at the same level as they were in the early 1990s, about five to seven missions a year.

| Table 2. ELVP Employment, FY 1990-2000 | | | |
|---|-------------------------|---------------------------------|------------------------------------|
| Year | Total Employment | Civil-Service Employment | Support Service Contractors |
| Actual: | | | |
| 1990 | 85 | 54 | 31 |
| 1991 | 96 | 62 | 34 |
| 1992 | 121 | 76 | 45 |
| 1993 | 109 | 73 | 36 |
| 1994 | 120 | 85 | 35 |
| 1995 | 121 | 82 | 39 |
| Projections: | | | |
| 1996 | 119 | 71 | 48 |
| 1997 | 122 | 73 | 49 |
| 1998 | 85 | 51 | 34 |
| 1999 | 62 | 36 | 26 |
| 2000 | 42 | 24 | 18 |

B. Payroll

Over the past five years combined (FY 1992-1996), total salaries for ELVP's civil-service employees amounted to \$23.3 million and employee benefits accounted for another \$5.1 million, constituting

a total compensation of \$28.4 million. As shown in Table 3, ELVP's 71 civil-service employees would earn \$5.6 million in salaries and benefits in FY 1996, for an average of \$78,800, which is almost 17% higher than the average salary and benefits paid to ELVP's workers four years earlier. In FY 1996, ELVP's average compensation (salary and benefits) was 12.2% higher than LeRC's average compensation. ELVP employs highly skilled workers, mainly scientists and engineers, which explains its high average salary and benefits.

| Table 3. ELVP Civil Service Salaries and Benefits, FY 1992- FY 1996 | | | | |
|--|--------------------------------|---------------------|--------------------|--------------------------------------|
| Year | Civil Service Employees | Salaries | Benefits | Average Salaries and Benefits |
| 1992 | 76 | \$4,202,403 | \$924,529 | \$67,460 |
| 1993 | 73 | 4,240,068 | 932,815 | 70,861 |
| 1994 | 85 | 5,144,063 | 1,131,694 | 73,832 |
| 1995 | 82 | 5,125,589 | 1,127,630 | 76,259 |
| 1996 | 71 | 4,586,301 | 1,008,986 | 78,807 |
| Five-Year Total | | \$23,298,424 | \$5,125,654 | |
| Five-Year Average | | | | \$73,447 |
| | | | | |

C. Occupations

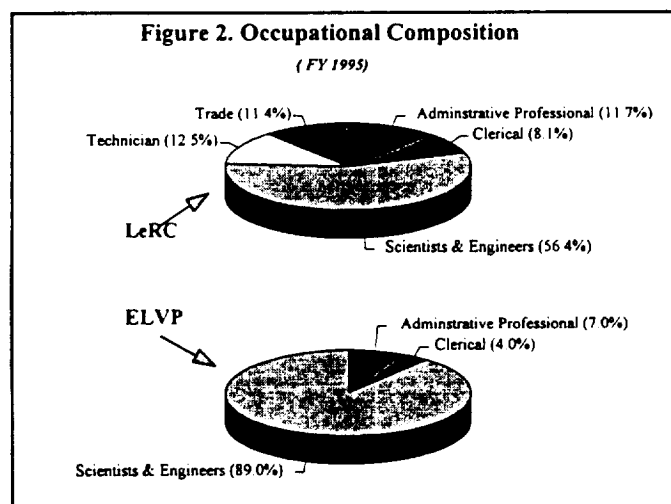
Civil-service employees at LeRC fall into five occupational groups: administrative professional, clerical, scientists and engineers, technician, and trades. Only the first three occupational categories are present in ELVP (Table 4). During the first half of the 1990s, administrative professional and clerical positions remained relatively stable, while the number of scientists and engineers working for the ELVP increased by 62% between FY 1990 and FY 1995. As a result, science and engineering jobs increased as a share of ELVP employment, while the share of the two other occupational categories declined (Table 5).

| Table 4. ELVP Civil-Service Employment, FY 1990-2000 | | | | |
|--|-------|-------------------------------|-----------------------------|----------|
| Year | Total | Major Occupational Categories | | |
| | | Scientists & Engineers | Administrative Professional | Clerical |
| Historical: | | | | |
| 1990 | 54 | 45 | 6 | 3 |
| 1991 | 62 | 54 | 5 | 3 |
| 1992 | 76 | 69 | 4 | 3 |
| 1993 | 73 | 65 | 4 | 4 |
| 1994 | 85 | 76 | 6 | 3 |
| 1995 | 82 | 73 | 6 | 3 |
| Projections: | | | | |
| 1996 | 71 | 63 | 5 | 3 |
| 1997 | 73 | 65 | 5 | 3 |
| 1998 | 51 | 45 | 3 | 3 |
| 1999 | 36 | 31 | 3 | 2 |
| 2000 | 24 | 20 | 2 | 2 |

Figure 2 indicates that in FY 1995, scientists and engineers accounted for 89% of ELVP employees, a significantly higher share than at LeRC as a whole (56%). As discussed earlier, this explains the higher average salaries and benefits received by ELVP employees compared with LeRC's average compensation per employee.

As mentioned earlier, it is projected that between FY 1995 and FY 2000, civil-service employment at ELVP would decline by 58 employees, or 71%. Over 90% of these losses would be among scientists and engineers, by far the largest category of ELVP employees. The projected losses of ELVP scientists and engineers account for one-fourth of the estimated scientist and engineer losses in LeRC as a whole. If these job losses materialize, they will have a significant effect on the Northeast Ohio economy, because LeRC is one of the region's main employers of scientists and engineers, especially in aeronautics and hard sciences.

| Table 5. ELVP Civil-Service Employment, FY 1990-2000 | | | | |
|--|-------|---|-----------------------------|----------|
| Year | Total | Major Occupational Categories (percent) | | |
| | | Scientists & Engineers | Administrative Professional | Clerical |
| Historical: | | | | |
| 1990 | 54 | 83% | 11% | 6% |
| 1991 | 62 | 87% | 8% | 5% |
| 1992 | 76 | 91% | 5% | 4% |
| 1993 | 73 | 90% | 5% | 5% |
| 1994 | 85 | 89% | 7% | 4% |
| 1995 | 82 | 89% | 7% | 4% |
| Projections: | | | | |
| 1996 | 71 | 89% | 7% | 4% |
| 1997 | 73 | 89% | 7% | 4% |
| 1998 | 51 | 88% | 6% | 6% |
| 1999 | 36 | 86% | 8% | 6% |
| 2000 | 24 | 84% | 8% | 8% |

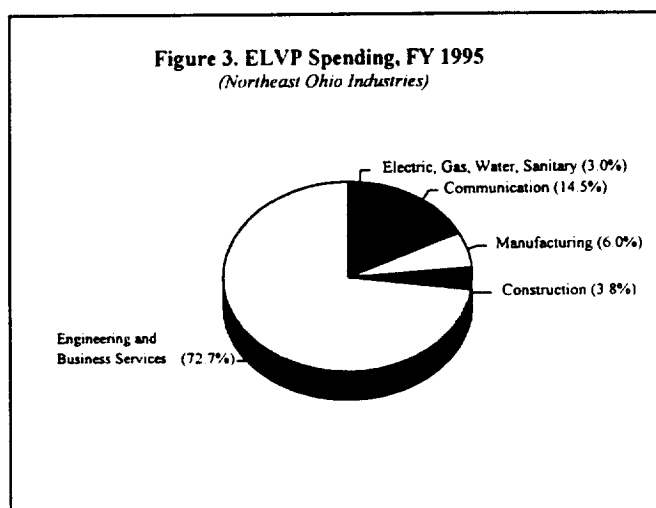


3. ELVP Spending on Contractors/Suppliers

Over the ten-year period, FY 1991-2000, total ELVP spending in Northeast Ohio is estimated to amount to \$59 million. This amount accounts for about 5% of ELVP spending on contractors. ELVP's prime contractor is Lockheed Martin, which is located in Denver, Colorado. Table 6 describes ELVP total spending on contractors located in Northeast Ohio for each of the ten years. It projects a severe decline between FY 1997 and FY 1998 and continued smaller declines until the end of the decade.

| Table 6: ELVP Total Spending on Contractors in Northeast Ohio, 1991-2000 | |
|---|-----------------|
| Year | Spending |
| Actual: | |
| 1991 | \$5,103,400 |
| 1992 | 6,869,800 |
| 1993 | 6,050,300 |
| 1994 | 7,515,200 |
| 1995 | 7,615,300 |
| Projections: | |
| 1996 | 7,135,000 |
| 1997 | 6,262,500 |
| 1998 | 4,704,400 |
| 1999 | 4,045,800 |
| 2000 | 3,677,000 |
| | |
| Ten-Year Total: | \$58,978,700 |
| | |

The ELVP spent \$7.6 million in FY 1995 purchasing goods and services from local companies in Northeast Ohio. Similarly to LeRC's spending patterns, the economic sector in Northeast Ohio that benefitted the most from ELVP's contractor spending is engineering and business services, which surpasses all other industries by a wide margin. Almost three-fourths (73%) of ELVP's local spending was for purchasing engineering and business services; LeRC's spending on engineering and business services accounted for 66% of its contractors' spending in Northeast Ohio. These contractors provide engineering services, scientific services, environmental services, logistics and administrative support. The other industry where ELVP spent more than one million dollars locally in 1995 was communication, which includes network maintenance and a portion of telecommunication, accounting for almost 15% of local spending (see Figure 3).



Northeast Ohio companies providing engineering and business services to ELVP received \$5.5 million during 1995. As Table 7 shows, other industries which benefit significantly from ELVP spending are communication (\$1.1 million), and manufacturing industries (\$460,000).

| Table 7: ELVP Spending in Northeast Ohio by Major Industry, 1995 | |
|---|----------------------|
| Industry | Spending (\$) |
| Engineering and Business Services | 5,535,130 |
| Communication | 1,105,952 |
| Manufacturing | 459,952 |
| Construction: New and Repair | 286,824 |
| Electric, Gas, Water, Sanitary | 227,392 |
| Total | 7,615,250 |
| | |

4. Taxes Paid by ELVP's Employees

Taxes that LeRC employees pay to the State of Ohio and to local communities are important to the state and local economies. These taxes are a function of the number of civil-service employees at LeRC, their place of residency, and their wages and salaries. Almost all of LeRC's employees reside in the Cleveland metropolitan area and 70% live in Cuyahoga County.

Estimated state and local income taxes paid by ELVP civil-service employees are presented in Table 8. During the five-year period from FY 1992 thru FY 1996, ELVP employees are expected to contributed \$1.4 million to state and local governments.⁸ One-third is paid to the local communities where ELVP employees reside or work and the other two-thirds is paid to the State.

⁸Average annual salaries for ELVP employees were used to estimate state and local income taxes. To calculate state taxes, average tax per employee derived from tax tables was multiplied by the number of employees. A 2% tax rate was assumed in calculating local taxes.

| Table 8. Estimated Income Taxes Paid by ELVP Civil-Service Employees to State and Local Governments, FY 1992 - FY 1996 | | | | |
|---|------------------------------------|-----------------------|----------------------------------|---------------------------------|
| | Civil-Service Employees | Total Salaries | Estimated Local Taxes | Estimated Ohio Taxes |
| 1992 | 76 | \$4,202,403 | \$84,000 | \$162,100 |
| 1993 | 73 | 4,240,068 | 84,800 | 166,300 |
| 1994 | 85 | 5,144,063 | 102,900 | 204,400 |
| 1995 | 82 | 5,125,589 | 102,500 | 205,700 |
| 1996 | 71 | 4,586,301 | 91,700 | 185,700 |
| Five-Year Total | | \$23,298,424 | \$465,900 | \$924,200 |
| | | | | |

IV. ELVP Total Economic Impact on the Northeast Ohio Economy

Economic impact studies measure both direct and indirect effects on the economy. The direct impact, described in the previous section (Section III), refers to an institution's spending on goods and services in the local economy, its sources of income, its employment, and taxes paid by the institution and its employees. The indirect impact is the effect of the institution's local spending and employment on other sectors of the local economy. The total economic impact estimated below measures ELVP's combined effects on Northeast Ohio's total output, total household earnings, and total employment.

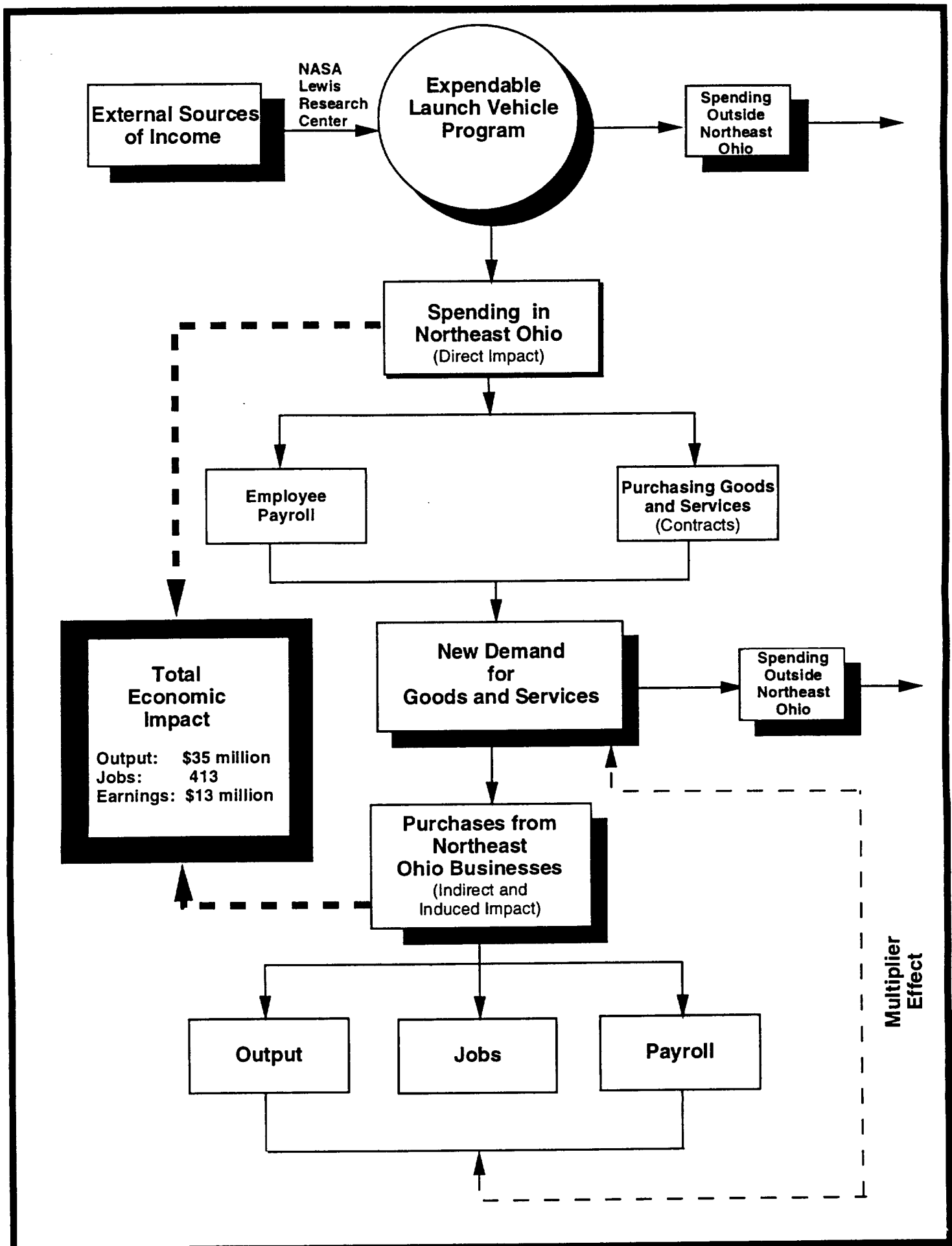
1. Methodology

Systematic analysis of economic impacts must take into account interindustry relationships within a region, because these relationships largely determine how a regional economy responds to changes in economic activity. These interindustry relationships are estimated by national and regional input-output (I-O) tables, which measure the industrial distributions of inputs purchased and outputs sold by each industry. Thus, it is possible to calculate how the impact of one dollar or one job "ripples" through the local economy, creating additional expenditures and jobs.⁹ The economic multiplier measures the ripple effect that an initial expenditure has on the local economy. Figure 4 describes the process by which ELVP affects the regional economy through its spending in Northeast Ohio.

This study utilizes regional I-O multipliers from the Regional Industrial Multiplier System (RIMS II) model developed by the U.S. Department of Commerce's Bureau of Economic Analysis. The

⁹For example, suppose that Company ABC sells \$1 million of goods. From the receipts of \$1 million, the company takes a profit, pays its suppliers, pays its labor force, and covers other production costs. Once the suppliers and employees receive their payments, they will spend a portion of the money in the local economy for needed goods and services, with another portion of funds going outside the local economy. By evaluating the chain of local purchases that result from the initial infusion of \$1 million, it is possible to estimate a regional economic multiplier.

Figure 4. Economic Impact of LeRC's Expendable Launch Vehicle Program



model provides regional industry multipliers that can be used to estimate the impacts of expenditures in one industry on regional output, earnings, and employment. This study uses RIMS II final demand multipliers to estimate ELVP's economic impact on Northeast Ohio based on its pattern of spending in the eight-county area.¹⁰ RIMS II is widely used in both the public and private sectors.

2. ELVP's Output (Spending) Impact

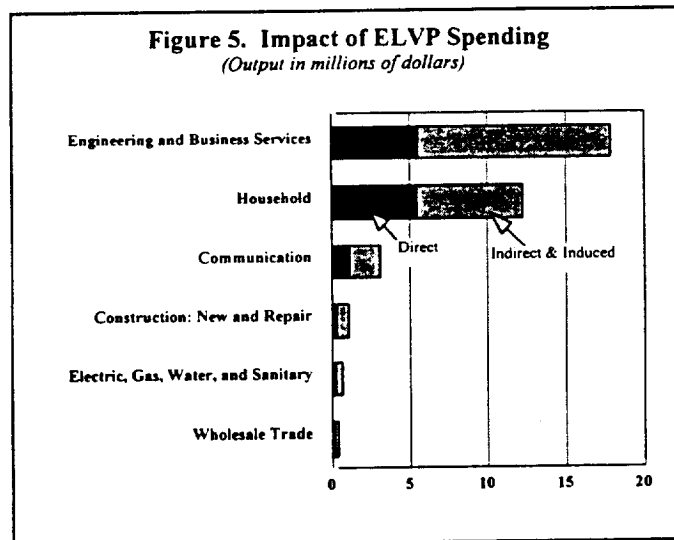
The final demand multipliers for output measure the effect of ELVP spending on gross receipts or sales in the region. ELVP spending is first divided into two segments: one, spending on goods and services purchased from companies located in Northeast Ohio, and two, spending for goods and services from businesses located elsewhere. Total local spending is then allocated into major industries. The RIMS II I-O model is used to calculate final demand multipliers for output for each of these industries.

The total impact of ELVP's local spending on output in Northeast Ohio is estimated by summing up individual industries' indirect output impacts. These are calculated by multiplying ELVP's local spending in each industry (the direct impact) by its corresponding multiplier. For example, as indicated in Table 9, the output impact of ELVP spending on engineering and business services in FY 1995 is \$12.2 million (\$5.5 million x 2.2021). The total output impact for each industry is composed of direct impact (ELVP spending on this industry) and indirect and induced impacts (Table 9 and Figure 5).

ELVP spending of \$12.7 million in Northeast Ohio increases economic output in the region by a total of \$22.1 million. Including its own spending, ELVP's total output impact in FY 1995 amounted to \$35 million.

¹⁰Final demand multipliers reflect three types of impact: direct impact, which represents the initial value of goods and services purchased by LeRC; indirect impact, which represents the value of goods and services purchased by local companies to provide goods and services demanded by LeRC; and induced impact, which measures the change in local household spending patterns resulting from increased earnings by employees in local industries producing goods and services for LeRC.

| Table 9. Output Impact of ELVP Spending, FY 1995 | | | |
|---|---------------------|------------|---------------------|
| Industry | Spending* | Multiplier | Impact |
| Total | \$12,716,313 | | |
| Engineering and Business Services | 5,535,130 | 2.2021 | 12,188,910 |
| Household | 5,463,878 | 1.2397 | 6,773,570 |
| Communication | 1,105,952 | 1.7831 | 1,972,023 |
| Construction: New and Repair | 286,824 | 2.2412 | 642,830 |
| Electric, Gas, Water, and Sanitary | 227,392 | 1.6739 | 380,631 |
| Wholesale Trade** | 97,137 | 1.9155 | 186,066 |
| Subtotal (Indirect and Induced Impact) | | | \$22,144,030 |
| Plus Direct Impact | | | \$12,716,313 |
| Total Impact | | | \$34,860,343 |
| Notes: *Spending on manufacturing industries as listed in Table 7 is excluded because the products purchased by ELVP were produced outside Northeast Ohio and only the wholesale portion of this spending enters into the multiplier process in the region. **Wholesale trade is calculated by multiplying spending on those goods (purchased locally and manufactured outside Northeast Ohio) by industry wholesale margins. | | | |



3. ELVP's Impact on Employment

The existence of the ELVP also has a local impact on jobs. As described earlier, ELVP employed 82 civil servants in FY 1995. The total job impact by industry is detailed in Table 10, where the RIMS II employment multipliers are based on 1992 dollars. For example, each \$1 million spent by ELVP on local engineering and business services created 41 jobs in the regional economy; thus, ELVP's expenditure of \$5.1 million (in 1992 dollars) on engineering and business services created 210 jobs throughout Northeast Ohio.

ELVP's local spending created 331 jobs in the Northeast Ohio economy, in addition to its own 82 civil-service employees. Thus, ELVP's total employment impact in FY 1995 amounted to 413 jobs.

| Table 10. Employment Impact of ELVP Spending, FY 1995 | | | |
|--|---------------------|------------|------------|
| Industry | Spending* | Multiplier | Impact |
| | (In 1992 dollars) | | |
| Total | \$11,772,531 | | |
| Engineering and Business Services | 5,124,323 | 40.9 | 210 |
| Household | 5,058,359 | 18.4 | 93 |
| Communication | 1,023,870 | 15.7 | 16 |
| Construction: New and Repair | 265,536 | 29.7 | 8 |
| Electric, Gas, Water, and Sanitary Services | 210,515 | 11.7 | 2 |
| Wholesale Trade** | 89,928 | 24.6 | 2 |
| Subtotal (Indirect and Induced Impact) | | | 331 |
| Plus Direct Impact | | | 82 |
| Total Impact | | | 413 |
| Notes: | | | |
| *Spending on manufacturing industries as listed in Table 7 is excluded because the products purchased by ELVP were produced outside Northeast Ohio and only the wholesale portion of this spending enters into the multiplier process in the region. | | | |
| **Wholesale trade is calculated by multiplying spending on those goods (purchased locally and manufactured outside Northeast Ohio) by industry wholesale margins. | | | |

4. ELVP's Impact on Household Earnings

Every new job created by ELVP's demand for Northeast Ohio's goods and services also generates new earnings for local households. The earnings multipliers for each industry estimate the total change in earnings that occurs in locally-employed households for each additional dollar of goods and services delivered to ELVP (Table 11). For example, the \$5.5 million ELVP spends on engineering and business services creates an additional \$4.8 million in earnings by households employed by Northeast Ohio businesses.

ELVP spending on contracts in FY 1995 generated \$7.6 million in earnings to Northeast Ohio households (in addition to payroll and benefits for its own civil-service employees). ELVP's total earnings impact in Northeast Ohio amounted to \$13 million in FY 1995.

5. Summary

ELVP's economic activities in FY 1995 produced the following economic impacts on Northeast Ohio:

| | |
|--------------------------|--------------|
| Total Output Impact: | \$35 million |
| Total Employment Impact: | 413 jobs |
| Total Earnings Impact: | \$13 million |

Table 11. Earnings Impact of ELVP Spending, FY 1995

| Table 11. Earnings Impact of ELVP Spending, FY 1995 | | | |
|--|--------------|------------|-----------|
| Industry | Spending* | Multiplier | Impact |
| Total | \$12,716,313 | | |
| Engineering and Business Services | 5,535,130 | 0.8652 | 4,788,994 |
| Household | 5,463,878 | 0.3614 | 1,974,646 |
| Communication | 1,105,952 | 0.4344 | 480,426 |
| Construction: New and Repair | 286,824 | 0.6754 | 193,721 |
| Electric, Gas, Water, and Sanitary Services | 227,392 | 0.3260 | 74,130 |
| Wholesale Trade** | 97,137 | 0.6224 | 60,458 |
| Subtotal (Indirect and Induced Impact) | \$7,572,374 | | |
| Plus Direct Impact | \$5,463,878 | | |
| Total Impact | \$13,036,252 | | |
| Notes: | | | |
| *Spending on manufacturing industries as listed in Table 7 is excluded because the products purchased by ELVP were produced outside Northeast Ohio and only the wholesale portion of this spending enters into the multiplier process in the region. | | | |
| **Wholesale trade is calculated by multiplying spending on those goods (purchased locally and manufactured outside Northeast Ohio) by industry wholesale margins. | | | |

V. Summary, Conclusions, and Recommendations

1. Major Findings

- The Expendable Launch Vehicle Program (ELVP), managed by the Lewis Launch Vehicle Project Office, was established in 1962 when the Atlas/Centaur program was transferred to Lewis Research Center (LeRC) from Marshall Space Flight Center in Alabama. LeRC was assigned to manage the Atlas/Centaur Program because of its expertise with liquid hydrogen and propulsion technology.
- ELVP's primary objective is to procure and manage launch services for government payloads launched on intermediate (Atlas/Centaur class) and large class launch vehicles (Titan IV class). ELVP's commercial launch services approach provides low cost, low risk launches for government payloads which are unique national assets that support planetary exploration, environmental science, solar science, weather monitoring, and communication.
- Since 1962, the ELVP has been responsible for 118 launches of Atlas, THOR, Titan, and other vehicles with various upper stages including Agena and Centaur; nine of these launches were test flights. ELVP's launched missions have been conducted with a high level of success over the past 30 years.
- Until the Challenger accident in 1986, Lewis Research Center's ELVP directly managed the Atlas/Centaur program. Following this accident, the National Space Policy was changed to encourage commercialization of space launches. To comply with the new policy, ELVP developed an innovative approach to implement the new commercial launch services, establishing a relationship between the prime contractor, who builds the launch vehicle, and NASA, ensuring the contractor's response to government needs.
- ELVP's heritage has been one of a long and successful venture for LeRC, advancing U.S. capabilities in space propulsion and successfully launching government payloads.
- Since the commercialization of space launches, ELVP has had a 100% launch success record. It has obtained launch service prices which are best in the government and are equivalent to or less than those paid by commercial satellite companies. Costs in a program of \$670 million increased by only 1.1% over the past eight and a half years.
- ELVP accounts for a large portion of LeRC's R&D budget but has relatively few employees. It accounted for 25% - 30% of LeRC's R&D budget during each of the past five years and for 2.7% of LeRC's total number of employees in FY 1995. The ELVP employed 121 people in FY 1995; 82 civil service employees and 39 contract employees.

- Over the five-year period, FY 1992-1996, total salaries and benefits of ELVP's civil service employees are estimated to reach \$28.4 million. In FY 1995, total salaries and benefits amounted to \$6.3 million. Average salary and benefits for an ELVP employee is estimated to be \$78,800 in FY 1996, a sum which is 12.2% higher than LeRC's average compensation.
- Scientists and engineers account for 89% of ELVP's employees, which is a significantly higher share than at LeRC as a whole (56%).
- Over the ten-year period, FY 1991-2000, total ELVP spending in Northeast Ohio is estimated to amount to \$59 million. This accounts for about 5% of ELVP total spending on contractors. ELVP's main contractor is Lockheed Martin, which is located in Denver, Colorado. Unfortunately, following mandated streamlining initiatives, total and local spending levels are projected to decline significantly between FY 1997 and FY 1998 and then continue to decline moderately until the end of the decade.
- During FY 1995, the ELVP spent \$7.6 million to purchase goods and services from Northeast Ohio companies. Similarly to LeRC's spending patterns, the economic sector in Northeast Ohio that benefitted the most from ELVP's contractor spending is engineering and business services. Of ELVP's local spending, 73% was for purchasing engineering and business services compared with LeRC's 66%. The only other industry where ELVP spent locally more than one million dollars in FY 1995 was communication, accounting for almost 15% of local spending.
- During the five-year period, FY 1992-1996, ELVP employees are expected to pay \$1.4 million in taxes to state and local governments. One-third is paid to local communities where ELVP employees reside or work and the other two-thirds is paid to the state of Ohio.
- ELVP's economic benefits to Northeast Ohio in FY 1995 amounted to a total output impact of \$35 million, total employment impact of 413 jobs, and a total earnings impact of \$13 million.

2. Conclusions and Recommendations

The Lewis Research Center's Expendable Launch Vehicle Program plays an important role in LeRC's mission of research, technology, and development in areas of aeropropulsion and selected space applications. LeRC is a major research and development producer and the ELVP accounts for one-fourth of its spending on R&D. Therefore, LeRC and the ELVP comprise a crucial part of Northeast Ohio's science and technology base.

If the ELVP relocates from Lewis to another NASA Center (as has been suggested by NASA Headquarters), LeRC's budget will decline significantly. A smaller LeRC budget would make it easier to justify additional budget cuts for a Center that already would have lost a fourth of its R&D budget and much of its expertise. LeRC's large economic impact on Northeast Ohio would decline if its budget, employment, and spending would decline significantly. LeRC's economic benefit to the regional economy is attested by its sizable total output impact of \$1 billion, employment impact of 12,800, and household earnings impact of \$375 million.

The Urban Center offers the following recommendations:

- LeRC's ELVP workforce, comprised largely of highly skilled scientists and engineers, offers collectively over 1,000 years of experience with expendable launch vehicles. If the ELVP were to transfer to another NASA Center, it could take years to replace this expertise, since many of these people may not relocate with the program. Considering LeRC's ELV expertise and long history of success with this program, NASA should weigh the benefits of moving the ELVP against possible adverse impacts, including added costs, increased risks, less skillful and experienced workforce, and employee morale.
- The exciting work of launching expendable vehicles to space is recognized by the public. However, ELVP's critical role in the success of these missions is not generally known to local leaders, communities, and the public. Thus, it is recommended that both LeRC and its ELVP make their achievements known to Northeast Ohio communities. LeRC and the ELVP should work more closely with key community organizations such as Cleveland Tomorrow and its Technology Leadership Council, the Greater Cleveland Growth Association, and the Ohio Science and Technology Commission to spread the word about ELVP's activities and successes.

- ELVP should foster relationships with area universities. One avenue to build new relationships could be through the Ohio Aerospace Institute (OAI). OAI is a private, non-profit, university-industry-government consortium that includes LeRC in Cleveland, Wright-Patterson Air Force Base in Dayton, nine Ohio universities, and technology driven corporations. Through OAI, or working directly with individual universities, ELVP's scientists and engineers could expose graduate students to rocket science in general and to expendable launch vehicles technology in particular. This strategy would provide a unique contribution to the education level in Ohio as well as expose universities' faculty, graduate students, and staff to ELV missions.

Appendix A: LeRC Launch History by the Launch Vehicle Project Office

THOR/Agena

| | |
|------------|------|
| Echo II | 1964 |
| Nimbus I | 1964 |
| OGO II | 1965 |
| Isis-X | 1965 |
| Nimbus II | 1966 |
| Pageos I | 1966 |
| OGO IV | 1967 |
| Nimbus B | 1968 |
| Nimbus III | 1969 |
| OGOG VI | 1969 |
| SERT II | 1970 |

Atlas/Agena

| | |
|-------------------|------|
| Ranger VI | 1964 |
| Fire I | 1964 |
| Ranger VII | 1964 |
| OGO I | 1964 |
| Mariner III | 1964 |
| Mariner IV | 1964 |
| Ranger VIII | 1965 |
| Ranger IX | 1965 |
| Fire II | 1965 |
| OAQ I | 1966 |
| OGO III | 1966 |
| Lunar Orbiter I | 1966 |
| Lunar Orbiter II | 1966 |
| ATS I | 1966 |
| Lunar Orbiter III | 1967 |
| ATS II | 1967 |
| Lunar Orbiter IV | 1967 |
| Mariner V | 1967 |
| Lunar Orbiter V | 1967 |
| ATS III | 1967 |
| OGO V | 1968 |
| SEASAT | 1978 |

Atlas/Centaur

| | |
|-----------------|---------|
| 8 Test Flights | 1962-66 |
| 7 Surveyors | 1966-68 |
| 2 ATS | 1968-69 |
| 3 OAO | 1968-72 |
| 4 Mariner Mars | 1969-71 |
| 8 Intelsat IV | 1971-75 |
| 6 Intelsat IVA | 1975-78 |
| Pioneer F(10) | 1972 |
| Pioneer G(11) | 1973 |
| MVM | 1973 |
| 4 Comstar | 1976-81 |
| HEAO A | 1977 |
| HEAO B | 1978 |
| HEAO C | 1979 |
| 8 FLSATCOM | 1978-89 |
| 2 Pioneer Venus | 1978 |
| 6 Intelsat V | 1980-83 |
| 4 Intelsat VA | 1984 |
| CRRES | 1990 |
| GOES I | 1994 |
| GOES J | 1995 |
| SOHO | 1995 |

Atlas H

| | |
|------------|------|
| Classified | 1983 |
| Classified | 1983 |
| Classified | 1984 |
| Classified | 1985 |
| Classified | 1987 |

Titan/Centaur

| | |
|-------------|------|
| Test Flight | 1974 |
| Helios A | 1974 |
| Viking A | 1975 |
| Viking B | 1975 |
| Helios B | 1976 |
| Voyager 1 | 1977 |
| Voyager 2 | 1977 |

Titan III/TOS

Mars Observer 1992

Appendix B:

Success History of ELVP's Operational Missions

| Vehicle | No. Successes / No. Flights | % Successes |
|---|-----------------------------|-------------|
| Thor/Agena | 10/11 | 91% |
| Atlas H | 5/5 | 100% |
| Atlas/Agena | 21/22 | 95% |
| Atlas/Centaur | 57/64 | 89% |
| Titan III/Centaur | 6/6 | 100% |
| Titan III/TOS * | 1/1 | 100% |
| | | |
| Total | 100/109 | 92% |
| | | |
| Note: Table excludes nine test flights. * TOS upper stage not managed by LeRC. | | |